LOTS Technology

Improved Data Storage via an Optical Tape Drive

In the mid-1990s, optical tapes held about 200 to 300 gigabytes of data. If optical tapes were going to be a viable alternative to magnetic tape technology, improvements in storage capacity would be necessary. LOTS (Laser Optical Tape Storage) Technology wanted to develop digital data storage technology that used a laser to write data quickly on high-density optical tape, a process that would be much faster than the current magnetic tape technology. Because optical tape technology was new in the late 1980's funding was extremely difficult to obtain from venture capital sources. Therefore, the company applied for and received funding from the Advanced Technology Program's (ATP) focused program, "Digital Data Storage," in 1995. LOTS' project goals included developing a thinner, higher capacity optical tape and a new writing head that used a green laser split into 64 beams that would write data to the tape. This writing head could record more data on more tracks on optical tape than could a writing head used for magnetic tape. If a breakthrough using optical tape could be achieved, researchers hoped to attain one terabyte of storage on a single tape, which was a very ambitious goal. The new technology would help U.S. government agencies and commercial industries store their information much more efficiently.

The project researchers demonstrated several of their technical accomplishments to the Institute of Electrical and Electronics Engineers at the Mass Storage Conference in 1997. The company also received one patent for the ATP funded technology and published one article. However, the venture capital group that was scheduled to assist LOTS in its commercialization effort pulled its funding in late 1997. After the project ended in 1997, LOTS received two grants from another government agency to further develop the technology, but was unable to find additional investors to move to commercialization. Subsequently, LOTS declared bankruptcy in 2003. Imation, a tape technology industry leader, bought the one patent generated from this project and equipment from LOTS at auction, but has not yet developed a product. As of 2005, the digital storage industry was focused on two alternative technologies for optical data storage, the compact disc (CD) and the digital video disc (DVD).

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)

No Stars

Research and data for Status Report 95-03-0023 were collected during November 2004 – March 2005.

Digital Optical Tape Thought to Be Superior to Magnetic Tape

The data storage challenges of the late 20th and early 21st centuries have been problematic for two reasons: 1) the volume of data that needs to be archived from many sources in industry, medicine, education, and government is high; and 2) the storage medium to meet archival-quality standards is inadequate (that is, a medium that can economically store as much data as possible for as long as 50 years at a minimum and 100 years at best). Paper, microfiche, and magnetic tape are examples of storage media that do not meet archival-quality standards in regards to storage capacity.

LOTS (Laser Optical Tape Storage) Technology, founded in 1993 to develop optical storage tape,

wanted to perfect optical tape, which had a much higher data storage capacity than magnetic tape. LOTS proposed to replace magnetic tape and other data storage media, such as paper or microfiche, with high-density optical tape. Another improvement optical tape offered was that the data could be written to the tape much faster, on a smaller area of the tape, than was possible with magnetic-tape data-writing technology. This meant that more data could be stored on optical tape than on magnetic tape. Furthermore, LOTS' proposed optical tape technology would enable faster archival transfer of data from short-term media such as paper and magnetic tape to optical tape. Finally, LOTS hoped to improve the "access time" of retrieving recorded data. (Access time is how long it takes the tape reel to find specific data on a tape.) The company hoped to reduce an average access time of 45 seconds for magnetic tape to less than 10 seconds with optical tape. Achieving the fastest possible data-write and data-read access times for optical tape would be a remarkable achievement for the data storage industry, especially considering how much greater amount of data would be stored on the optical tape.

LOTS proposed to replace magnetic tape and other data storage media, such as paper or microfiche, with high-density optical tape.

Because optical tape technology was new, venture capital for this high-risk research was limited. Therefore, LOTS applied for and received ATP funding under the "Digital Data Storage" focused program of 1995. If the optical tape technology proved to be an economical solution, U.S. banking, health, medicine, industry, government, and personal records could be transferred to this more efficient storage medium.

LOTS Identifies Project's Technical Goals

One of the project's major technical goals was to adapt a commonly used magnetic tape cartridge manufactured by IBM Corporation for use with optical tape to hold one terabyte, or one trillion bytes, of data. LOTS wanted to use optical tape in the cartridge onto which up to as many as 64 tracks could be simultaneously written with multiple, independently controlled, short-wavelength laser beams. Another advantage it offered was the speed with which data could be written to the tape with a laser, provided that a laser-writing head could be developed (another of LOTS' technical goals). The writing head would direct the laser beams that wrote the data to the tape.

Other technical goals of the project included the following:

- Develop a beam-splitter device to split the laser into 64 beams to write separately on 64 tracks on the tape. (If this worked, up to 180 beam splits would be attempted in the next stage.) This goal was risky because this type of beam splitter was not commercially available. Project researchers, with subcontractors Radiant Technologies of Albuquerque, New Mexico and the University of California at San Diego, would develop the beam-splitter in parallel with their work on the other project goals.

- Develop a modulator that would enable the 64 beams to write discretely within specific boundaries on the tape area. Because each beam had the same wavelength, this was a major technical challenge of the project. The data-writing goal for the project was to achieve a data-transfer rate of at least 100 megabytes per second (MB/s) to store more than 1 terabyte on the IBM cartridge. This meant that 64 beams would be writing simultaneously and independently to the tape. An efficient modulator design was needed to control each beam to keep its data recording properly separated during the recording process. Like the beam splitter, the modulator was not available commercially and needed to be developed by the project researchers. Subcontractor Northeast Photosciences helped with this task.

- Obtain a commercially available green laser of sufficient power and stability in a compact package.

Project Completes Majority of Its Technical Goals

The two-year ATP-funded project successfully completed most of its technical goals. Specifically, LOTS demonstrated the following achievements:

1) Rotated the optical tape media recording from the recording reel to the take-up reel at speeds more than sufficient for a 100-MB/s data-transfer rate.

2) Fabricated a laser beam-splitter to produce horizontal and vertical two-dimensional arrays of 64 laser beams from a single short-wavelength laser with acceptable efficiency.

3) Developed a means to produce two-dimensional (horizontal and vertical) arrays of modulators to keep each of the 64 lasers separate. Each modulator was highly efficient and had acceptable "rise and fall" times. (A "rise" time describes how long a modulator takes to fire the laser at full power after it is turned on. The "fall" time describes how long a modulator takes to power down a laser after it is turned off. The shorter the rise and fall times, the better the performance and the higher the efficiency of the array.)

4) Developed an optical system that integrated the short-wavelength laser and the modulator arrays to provide regular two-dimensional arrays of optical beams that could be modulated. (Modulation was necessary to ensure that enough lasers in the array were firing simultaneously to create enough power to record data with at least a 10-nanosecond rise time.)

5) Demonstrated the suitability of an Eastman Kodak-supplied optical tape for high data-rate recording and large-area data capacity.

The next step after completing these goals was to demonstrate a system using the beam-splitter, modulators, and optical tape that the team had developed. The demonstration was presented for the Institute of Electrical and Electronics Engineers at the Mass Storage Conference in 1997 and was well-received. But several challenges toward the end of the project forestalled the integration of the new components. First, in July 1997, researchers discovered that one technology for recording on optical tape was superior; pulse wave modulation (PWM) code was determined to be superior to pulse position modulation (PPM) code. But perfecting PWM was beyond the scope of the project, thus more research would be needed after the project ended. The second challenge that prevented component integration involved the read/write head and the laser modulators. By project conclusion, researchers had tested the read/write head and several laser modulators, and none of the laser modulators for incorporation into a complete recording system. Researchers concluded that the materials used by the vendors that manufactured the various modulators were of inferior quality. If better modulator suppliers could be found, the problem might be solved.

Researchers Make Post-Project Progress

From the end of the project in 1997 until 2003, LOTS attracted two funding awards totaling more than $2 million from another government agency to continue developing the technology resulting from ATP funding. While that agency was satisfied with LOTS' work, the company was not able to secure additional funding from investment partners to continue development.

While the project was still ongoing, the digital storage industry was also focused on an alternative technology, the compact disc (CD) and the digital video disc (DVD).

LOTS researchers accomplished several of their goals, such as reducing the average access time of recorded data to 10 seconds, an improvement of 35 seconds over the access speed at the start of the project.

Optical tape, as a viable commercial technology, needed further refinement to make it efficient, economical, and competitive. The technical risk continued to be too great to make optical tape ready for manufacture and sale. Many different technologies required breakthroughs before the optical tape system that LOTS tried to develop could be ready for product development. These challenges included the complexities of developing adequate optical modulators for the laser beam and more robust optical tape. At the same time, the CD/DVD was gaining global attention

within research communities. These factors effectively prevented quick success in manufacturing and commercializing optical tape technology. Although LOTS researchers accomplished several of their goals, such as reducing the average access time of recorded data to 10 seconds, an improvement of 35 seconds over the access speed at the start of the project, they were unable to develop an integrated system that demonstrated all their project goals.

By the end of the project LOTS received one patent for the technology developed during the ATP project. The company also published one article and presented its findings at the Electrical and Electronics Engineers at the Mass Storage Conference in 1997. After the project ended in 1998, LOTS received two grants from another government agency to further develop the technology, but was unable to find additional investors to move to commercialization. In 2003 LOTS declared bankruptcy. Imation, a tape technology industry leader, bought the one patent generated from this project and equipment from LOTS at auction, but has not yet developed a product.

Conclusion

LOTS (Laser Optical Tape Storage) Technology received ATP funding in 1995 to perfect the design of laser-writing of data to optical tape at a maximum recording speed and data storage density. Although the company achieved several of their project goals within two years and received more than $2 million in additional government agency funding, they did not succeed in overcoming the key technical barriers to commercialize this technology. Even after the additional funding, they were not able to attract private investment to further technology development, nor could they establish partnerships with tape industry manufacturers, as originally planned.

During the course of the project, the attention given by the industry to the digital compact disc (CD) and the digital video disc (DVD) helped make optical tape technology obsolete. While CD/DVD technology is more robust than optical tape, it has less storage capacity. As of 2005, the archival digital data storage industry was dominated by CD/DVD technology, but it still remained inadequate for record archives. The project produced one patent, one publication and one presentation.

PROJECT HIGHLIGHTS
LOTS Technology

Project Title: Improved Data Storage via an Optical Tape Drive (Digital Data Storage Technology via an Ultrahigh-Performance Optical Tape Drive Using a Short-Wavelength Laser)

Project: To develop an optical tape storage technology in which up to 180 tracks can be simultaneously written and read with multiple, independently controlled laser beams that could lead to data systems for rapidly storing, retrieving, and transferring 1 trillion bytes of information.

Duration: 9/1/1995 - 8/31/1997
ATP Number: 95-03-0023

Funding (in thousands):

ATP Final Cost	$1,950	80.0%
Participant Final Cost	488	20.0%
Total	$2,438	

Accomplishments: LOTS (Laser Optical Tape Storage) Technology was not able to develop an integrated optical tape storage system but it was able to develop the following components:

- Rotated the optical tape media recording from the recording reel to the take-up reel at speeds more than sufficient for a 100-MB/s data-transfer rate
- Fabricated a laser beam-splitter to produce horizontal and vertical two-dimensional arrays of 64 laser beams from a single short-wavelength laser with acceptable efficiency
- Developed a means to produce two-dimensional (horizontal and vertical) arrays of modulators to keep each of the 64 lasers separate
- Developed an optical system that integrated the short-wavelength laser and the modulator arrays to provide regular two-dimensional arrays of optical beams that could be modulated. LOTS was not able to integrate its components into a complete optical tape storage system

The company received the following patent related to its ATP-funded technology:

- "High speed tape packing"
  (No. 6,719,238: filed June 15, 2001; granted April 13, 2004)

Commercialization Status: The digital data storage industry considers this technology too technically challenging. No commercialization has occurred.

Outlook: The focus in the industry has shifted to exploring digital data storage using digital video discs (DVDs) and compact discs (CDs). This industry shift makes the outlook poor for optical tape storage.

Composite Performance Score: No Stars

Number of Employees: 4 employees at project start; 0 as of March 2005.

Focused Program: Digital Data Storage, 1995

Company:
LOTS Technology is no longer in existence.

Contact: Joe Straub (former Principal Investigator for LOTS Technology)
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Subcontractors:

- Radiant Technologies
  Albuquerque, NM
- Northeast Photosciences
  Hollis, NH
- Eastman Kodak Company
  Rochester, NY
- University of California
  San Diego, CA

Publication:

- Aguilar, John. "LOTS Tech Carves Niche in Crowded Storage Space." Boulder County Business Report 20 (3), p. A9, February 9, 2001.

Presentation:

- The Institute of Electrical and Electronics Engineers at the Mass Storage Conference, 1997.